REMARKS/ARGUMENTS

Amendment of the Claims

Insofar as they were not already so limited, the independent claims have been amended so that they are limited to

(1) carbonyl-containing polymers containing at least 5% by weight of repeating units derived from an alkyl acrylate, and

(2) vinylidene fluoride (VDF) copolymers.

Consequential amendments have been made to dependent claims 42, 43, 65 and 66. Basis for this restriction of the claims is on page 3, lines 15-18, of the PCT specification.

The Rejections under 35 USC 103

Applicant respectfully traverses the rejection under 35 USC 103 of

(1) claims 28, 31, 32, 37, 40, 42, 43, 46, 57, 60, 62 and 64-67, over GB 1,117,180 (hereinafter "Lanza") in view of US 4,049,904 (hereinafter "Hori"),

(2) claims 29, 30, 38, 39, 51-54, 58, 59, 63, 71, 74 and 75 over Lanza in view of Hori, and further in view of US 4,693,940 (hereinafter Vogdes),

(3) claims 33, 47, 50, 61, 68 and 70 over Lanza in view of Hori, and further in view of US 4,804,702 (hereinafter Bartoszek), and

(4) claims 48, 49 and 69 over Lanza, in view of Hori and Vogdes, and further in view of Bartoszek,

insofar as those rejections are applicable to the amended claims, for the following reasons.

Summary of Lanza and Hori

In all the rejections, the primary reference is Lanza, and the secondary reference is Hori.

Lanza discloses an insulated electrical wire comprising a metallic conductor and insulation around the conductor, the insulation being made up of a first layer which is adjacent

the metallic conductor and a second layer, both layers being cross-linked (page 1, lines 50-67). The first layer is composed of an olefin polymer, and it is stated that the olefin polymer can be "a copolymer of an olefin with any copolymerizable monomer, for example copolymers of ethylene with butene-1, or vinyl acetate" (page 1, lines 68-72). However, polyethylene is the only polymer which is used in the specific Examples. The second layer is stated to be composed of a "vinylidene fluoride homopolymer or copolymer", but only polyvinylidene fluoride (i.e. the homopolymer, PVDF) is used in the specific Examples. The thickness of the first layer is at least 3 mils (0.003 inch, or 75 μ), and thickness of the second layer is at least 1.5 mils (0.0015 inch, or 25 μ), i.e. a combined minimum thickness of 100 μ (page 2, lines 35-39). The thicknesses of the layers in the specific Examples are several times those minimum values. Claim 5 refers to the possibility of cross-linking the two layers simultaneously, but in the only procedure specifically described (in the Examples) the cross-linking of the polymeric layers is carried out in two distinct steps. In the first step, the first insulating layer is irradiated on its own (i.e. before the second insulating layer is applied), and is thus cross-linked in the absence of the second insulating layer. In the second step, the second insulating layer is irradiated, thus cross-linking it.

Lanza does not state that his procedure results in cross-linking of the polymers across the interface between the layers, and in fact, as noted on page 1, lines 20-30, of the PCT specification insulated wires made by the Lanza procedure "have negligible adhesion between the inner (polyolefin) and outer (PVDF) layers, which are consequently easily separable", and in consequence suffer from a number of serious disadvantages, including the liability of the outer layer to "crack and peel off the inner layer..." and a detrimental effect on the "abrasion and flexural fatigue resistance... (and) resistance to wrinkling".

There is no disclosure in Lanza that the olefin polymer can be a copolymer of an olefin and an alkyl acrylate. There is no disclosure in Lanza that the VDF polymer can be a copolymer of PDF and hexafluoropropylene.

Hori discloses a laminate which is designed for use as a shielding layer or a thin film capacitor (column 5, lines 35-38) and which comprises a metallic foil, a first polymeric layer

which is adjacent to the metal foil, and a second polymeric layer adjacent to the first layer. The thickness of the metallic foil is 100-250 μ and the combined thickness of the two polymeric layers is 45-75 μ (column 3, lines 32-36).

The polymer in the first layer is formulated to adhere well to the metallic foil, and is stated to be "selected from group consisting of ethylene-unsaturated carboxylic acid copolymers, ethylene-unsaturated carboxylic acid ester copolymers, ionomers containing these copolymers as the base, and graft copolymers of polyethylene and unsaturated carboxylic acids" (column 1, lines 49-56). In the specific Examples, the polymer in the first layer is an ionomer, an ethylene-acrylic acid copolymer or an ethylene-ethyl acrylate copolymer. The polymer in the second layer is formulated to adhere well to the first layer and to polyolefins, and is stated to be "selected from the group consisting of polyethylene, ethylene-vinyl acetate copolymers, ethylene-unsaturated carboxylic acid ester copolymers, and graft copolymers of polyethylene and unsaturated carboxylic acid esters" (column 1, lines 57-63). According to column 2, lines 32-40, and column 3, lines 3-9, when the polymer is an ethylene-unsaturated carboxylic acid ester copolymer, the ester can be ethyl, propyl or butyl acrylate or methacrylate (in which case the amount of the ester should be less than 20%) or vinyl acetate (in which case the amount of the ester should be less than 30%.

In Hori's claims, the definitions of the first and second polymers are much narrower; the first polymer must be an ionomer, and the second polymer must be an ethylene-vinyl acetate copolymer or an ethylene-unsaturated carboxylic acid ester copolymer. In Hori's specific Examples, the polymer in the first layer is an ionomer, an ethylene-acrylic acid copolymer or an ethylene-ethyl acrylate copolymer, and the polymer in the second layer (which is different from the polymer in the first layer) is an ethylene-vinyl acetate copolymer, polyethylene, an ionomer or an ethylene-acrylic acid copolymer.

Hori's laminate is prepared by making a composite film of the two polymeric layers,, subjecting the composite film to "adhesion treatment by corona discharge, oxidizing flame or chemicals" (column 4, lines 40-45) and then laminating the composite film to the metallic foil

(column 4, lines 9-63). One or both surfaces of the metallic foil can be laminated to a composite film (see Figures 1 and 2).

As noted above, Hori's laminate is designed for use as a shielding layer for a communications cable, the laminate being wrapped around the insulating jacket of a communication cable or as a thin film capacitor (see for example Figure 3, column 3, lines 42-51, and column 4, line 64-column 5, line 22). It is well known to those skilled in the art that in such uses the metallic film does not, and cannot, function as a current-carrying conductor. Thus, a metallic foil having a thickness of 100-250 μ, as disclosed by Hori, has a very high longitudinal resistance. The product characteristics and functionality of Hori's laminate are, therefore, entirely different from the insulated wires which are disclosed in Lanza, and which are the subject of the present claims.

The Office Action states, on page 3,

*Hori teaches a **wire** comprising...* (emphasis added)

That is not correct. The metallic foils disclosed by Hori are not wires, since they cannot function as current-carrying conductors. For the avoidance of doubt, the following definitions were found in a search on the web for a definition of the term "wire".

A metal conductor that carries electricity over a distance.

A wire is a single, usually cylindrical, elongate strand of drawn metal. Wires are used to bear mechanical loads and to carry electrical energy and/or communications signals.

Singled solid or stranded group of conductors having a low resistance to current flow.

A copy of the search is attached. Also attached is an article by the OkoniteCo. discussing shielding.

Lanza and Hori Cannot Properly Be Combined

It is well recognized that

(a) a rejection under 35 USC 103 cannot properly be based upon a combination of two (or more) references unless there is "some teaching, suggestion or motivation" to combine the references, and

(b) the initial burden is on the Examiner to show that there is such teaching, suggestion or reason.

(MPEP 706.02 (j) and 2142; in re Kahn (Fed. Cir.2006, 04-1616).

The Examiner has not asserted that there is any teaching, suggestion or motivation to combine Lanza and Hori, and the rejection should be withdrawn for that reason alone. Furthermore, consideration of the relevant facts makes it clear that there is not in fact any teaching, suggestion or motivation to combine Lanza and Hori.

The claimed invention is concerned with "an insulated electrical wire", i.e. a conventional current-carrying conductor. The problem faced by the inventor, before making the invention, was how to improve the properties of an insulated wire adversely affected by the lack of adhesion between an insulating layer of a polyolefin and an insulating layer of a polyvinylidene fluoride (PVDF), while still preserving the good resistance to crack propagation which was attributed to that very lack of adhesion – see page 1, line 20 to page 2, line 13 of the PCT specification. Hori, on the other hand, is concerned with a metallic foil-containing laminate which is useful as a shielding layer or a thin film capacitor. As noted above, the functionality required in a current-carrying conductor is completely different from the functionality required in a shielding layer or a thin film capacitor. It is clear, therefore, that Hori is not in the field of the Applicant's endeavor. It also clear that Hori has no pertinence to the problem faced by the inventor. Thus, there is no reference in Hori to any vinylidene fluoride polymer, still less the adhesion between a layer of a vinylidene fluoride polymer and a layer of a polyolefin. Under these circumstances, there is no reason why one of ordinary skill in the art would have considered modifying Lanza by incorporating the teaching of Hori. Applicant submits, therefore, that Lanza and Hori cannot properly be combined, and that all the rejections should be withdrawn

Even If Lanza and Hori Can Properly Be Combined, the Combination Does Not Disclose the Claimed Invention.

Even if, contrary to Applicant's submission, Lanza and Hori can properly be combined, the combination does not disclose the claimed invention. Hori does disclose a polymeric layer in which the polymer is an ethylene-alkyl acrylate copolymer. But that disclosure is only in combination with a metallic foil and another polymeric layer of specified composition in order to make a laminate which is suitable for use as a shielding layer or a thin film capacitor. Hori is not concerned with the provision of insulation for a current-carrying conductor, which is Lanza's only concern. Nor can Hori's other polymeric layer be composed of a vinylidene fluoride polymer, as is essential in Lanza.

Under these circumstances, it is clear that the Examiner's assertion that it would have been obvious to make use of Hori's s ethylene-alkyl acrylate copolymer as Lanza's olefin polymer cannot be sustained, since it is contrary to the well-settled law that

> *it is impermissible within the framework of section 103 to pick and choose from any one reference only so much of it as will support a given position, to the exclusion of other parts necessary to the form appreciation of what such reference fairly suggests to one of ordinary skill in the art.*
>
> In re Wesslau 147 USPQ 391.

The Rejections which include the Vogdes and/or Bartoszek References.

Many of the rejections make use of one or both of Vogdes and Bartoszek, in addition to the combination of Lanza and Hori. It is clear that these rejections should also be withdrawn for the reasons set out above. However, for the sake of completeness, the following additional comments are made on the rejections which include reliance on Vogdes.

As noted above, and as acknowledged by the Examiner, Lanza fails to describe any procedure which results in a cross-linking of polymers at the interface between the two polymeric

layers. Vogdes is relied upon to make good this deficiency in the rejection of those claims which require this feature.

Summary of Vogdes

Vogdes discloses a process in which a laminate comprising adjacent layers of incompatible polymers is irradiated, thus improving the adhesion between the layers. One layer can be composed of a vinylidene fluoride polymer and the other of an ethylene-ethyl acrylate copolymer. While the laminate is being irradiated, it is a freestanding article, not an insulating coating on a substrate. The irradiated laminate is particularly useful when it is in the form of a heat-recoverable sleeve, especially for electrical insulation; when so used, the length of such insulation is of course limited to the length of the heat-recoverable sleeve.

Lanza and Vogdes cannot Properly be Combined.

Initially, it is noted that, as with the proposed combination of Lanza and Hori, the Examiner has not asserted that there is any teaching, suggestion or motivation to combine Lanza and Vogdes. The rejections including Vogdes should be withdrawn for that reason alone.

Furthermore, consideration of the relevant facts makes it clear that there is not in fact any teaching, suggestion or motivation to combine Lanza and Vogdes. As noted above, and as further discussed below, Vogdes is directed to the preparation of a laminate, particularly a laminate in the form of a heat-shrinkable sleeve. The functionality required in a current-carrying conductor is completely different from the functionality required in a heat-shrinkable sleeve. It is clear, therefore, that Vogdes is not in the field of the Applicant's endeavor. It also clear that Vogdes has no pertinence to the problem faced by the inventor. As noted above, the problem faced by the inventor, before making the invention, was how to improve the properties of an insulated wire which were adversely affected by the lack of adhesion between an insulating layer of a polyolefin and an insulating layer of a polyvinylidene fluoride (PVDF), while still preserving the good resistance to crack propagation which was attributed to that very lack of adhesion – see

page 1, line 20 to page 2, line 13 of the PCT specification. Since Vogdes is concerned with a laminate in which the resistance to crack propagation is not a relevant issue, Vogdes is clearly not directed to the problem faced by the inventor. Under these circumstances, there is no reason why one of ordinary skill in the art would have considered modifying Lanza by incorporating the teaching of Vogdes. Applicant submits, therefore, that Lanza and Vogdes cannot properly be combined, and that all the rejections which include Vogdes should be withdrawn.

Even If Lanza, Vogdes and Hori Can Properly Be Combined, the Combination Does Not Disclose the Claimed Invention.

Since the free-standing laminates irradiated by Vogdes are different from the insulated wires irradiated by Lanza, it would not have been obvious to one of ordinary skill in the art to replace Lanza's procedure by Vogdes procedure. Indeed, to do so would change the principle of operation of Lanza, since Vogdes procedure requires that the two polymeric layers should be irradiated in the absence of any metal substrate. As noted in MPEP 2143.01, such teaching is not sufficient to render the claims *prima facie* obvious.

At the end of paragraph 6 of the Office Action, the Examiner asserts that "it would have been obvious to one of ordinary skill in the art at the time the invention was made to coextrude the layers of Lanza because such method is standard/known in the art". This assertion, however, overlooks the fact that coextrusion is not referred to in Lanza, and that the only radiation procedure disclosed by Lanza requires that the two layers should be separately extruded and cross-linked, with the first layer being cross-linked by radiation before the second layer is applied (and subsequently cross-linked by radiation). Clearly, Lanza's preferred procedure cannot be applied when the two layers are coextruded.

Even if any of the reference combinations (Lanza and Hori; Lanza, Hori and Vogdes; Lanza, Hori and Bartoszek; and Lanza, Hori, Vogdes and Bartoszek) can properly be made, and provide a proper basis for the prima facie rejection of any of the claims, that

***prima facie* rejection should be withdrawn in view of the evidence in the specification that the claimed invention provides unexpected advantages.**

The experimental results on pages 6-12 of the specification convincingly demonstrate that the claimed invention provides excellent and unexpected properties, in particular by comparison with an insulated wire made according to Lanza, which is the closest prior art. Thus, the specification demonstrates, on pages 9-12, that in a range of tests (scrape abrasion resistance, cold impact assistance and solvent resistance) the insulated wires claimed in the present invention have properties that are unexpectedly superior to the commercially available products made according to Lanza.

CONCLUSION

It is believed that this application is now in condition for allowance, and Applicant respectfully requests that a timely Notice of Allowance be issued in this case. If, however, there are any outstanding issues that could usefully be discussed by telephone, the Examiner is asked to call the undersigned.

Respectfully submitted,

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Web

Related phrases: wire transfer american wire gauge wire side drop wire ground wire wire service wire speed piano wire fly-by-wire four-wire circuit

Definitions of **wire** on the Web:

- provide with electrical circuits; "wire the addition to the house"
- cable: send cables, wires, or telegrams
- ligament made of metal and used to fasten things or make cages or fences etc
- a metal conductor that carries electricity over a distance
- fasten with wire; "The columns were wired to the beams for support"
- string on a wire; "wire beads"
- the finishing line on a racetrack
- telegram: a message transmitted by telegraph
- electrify: equip for use with electricity; "electrify an appliance"
  wordnet.princeton.edu/perl/webwn

- A wire is a single, usually cylindrical, elongated strand of drawn metal. Wires are used to bear mechanical loads and to carry electrical energy and/or communications signals.
  en.wikipedia.org/wiki/Wire

- Wire is a British punk/experimental rock band formed in 1976 by Graham Lewis (bass, vocals), Bruce Gilbert (guitar), Colin Newman (vocals, guitar) and Robert Gotobed (drums).
  en.wikipedia.org/wiki/Wire_(band)

- Wire is the seventh album by Christian rock band Third Day. It breaks from the style of the band's previous albums to return to simple, rock and roll-driven melodies. To quote All Music Guide's review of the album, "Third Day has stripped away the shine and gotten back to the grittiness of being a rock & roll band." The album is largely carried by the energetic guitar riffs that pervade its songs, although the forceful lyrics also contribute significantly.
  en.wikipedia.org/wiki/Wire_(album)

- The finish line for the race.
  www.pbkennelclub.com/Racingterms.asp

- At the wet end of the paper machine, a copper, bronze or synthetic screen that receives the suspension of water and fiber from the head-box. The wire moves the suspension along to the dry end of the machine. The wire terminates at the couch roll at which point the paper web is 90% water and can be transferred to the wet felt. In business forms, to stitch or fasten sheets to form a book or fastened set; may be side or saddle wired.
  www.neenahpaper.com/Glossary/index.asp

- Another term for the finish line.
  www.harness.org.au/TERMS.HTM

- Single solid or stranded group of conductors having a low resistance to current flow. Used to make connections between circuits or points in a circuit.
  www.sciencelobby.com/dictionary/w.html

- A conductor of round, square, or rectangular section, either bare or insulated.
  www.electronicconcepts.ie/news_updates.asp

- Stories filed by news services such as The Associated Press or Reuters.

deseretnews.com/sesqui/175013778.html

- Flat belt of metal or plastic mesh on which the paper or board web is dewatered
  english.forestindustries.fi/glossary/W.html

- Front-line trenches were often protected by coils of barbed wire that prevented the enemy from entering the trench easily. Before a battle, the artillery would often be responsible for shelling the enemy wire in order to blow holes through which ground troops could pass. During trench raids, small sections of the enemy's wire would be cut open with hand-held clippers.
  www.collectionscanada.ca/firstworldwar/051806/0518062008_e.html

- An endless belt woven of plastic or metal for use an the fourdrinier machine; forming fabric.
  palimpsest.stanford.edu/byorg/abbey/ap/ap01/ap01-4/ap01-415.html

- (component) A single bare or insulated metallic conductor having solid, stranded, or tinsel construction, designed to carry current in an electric circuit.
  connectors.tycoelectronics.com/glossary/glossary-w.stm

- Hot or cold-drawn coiled rounds in varying diameter, usually not exceeding 0.25 in. (6.4 mm).
  www.metkos.com/steel/terminology.htm

- The continuous open mesh material (earlier, a bronze or copper woven wire screen), used on the paper machine to initiate the water removal process; the wire is the traveling surface and primary forming mechanism of the paper web. When the wire is made of synthetics/ plastics, it can also be called the fabric.
  www.newpagecorp.com/mpd/home.nsf/Glossary

- A definition of wire is just about the same as the definition for bar, in that wire can be almost any cross section, but, unlike bar, wire can be round. The major difference lies in the fact that the minor dimension for bar must be at least three-eighths of an inch (.375") while the major dimension for wire must be under three-eighths of an inch.
  www.tennalum.com/Glossary.htm

- Other costs that are incurred when a real estate loan is closed.
  www.stlagent.com/resource/dict_i.html

- Lots of wire in slot racing. Under the track, in the controller, connecting the guide to the motor, and wrapped around the arm. 12 or 10 guage is used under the track, always stranded. DC current travells along the outside surface of the wire, and because of that, all wire used in slot racing except for that wrapped around the armature is stranded. This gives the current many different outside surfaces to travell along, increasing effeciency.
  www.scaleautoracing.com/slotfaqs/gw.html

- In an automatic sprinkler system, low voltage direct burial wire is used to connect the automatic control valves to the controller. The most frequently used wire for commercial applications is single strand, heavy gauge direct burial copper wire. (The larger the gauge number, the thinner the wire.) The most frequently used wire for the home sprinkler system is multi-strand. Color-coded, multi-strand sprinkler wire has several coated wires together in one protective jacket.
  www.hunterindustries.com/Resources/Glossary/glossary_qz.html

- There are many kinds of wire: Plain Smooth. High tensile Very strong wire, usually 121/2 gauge (2.5 mm). No.8 wire Smooth wire, 8 gauge (4mm). Barbed Two smooth wires into which barbs are spun at intervals.
  www.ees.adelaide.edu.au/icooper/glossary/w.htm

- Slender metal rods of round, ovalized or waisted cross section applied to restrain cotton bales after compression.
  www.cotton.org/tech/bale/specs/definitions.cfm

- a line bounded by points, it is only a construction element and NOT a Solid or Surface object, does not contain volume.
  campus.champlain.edu/faculty/demarle/351_01.htm

Find definitions of **wire** in: **English** German Spanish all languages

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THE OKONITE COMPANY

Shielding Discussion

Shielding should be considered for non-metallic covered cables operating at a circuit voltage above 2000 volts for single conductor cables and 5000 volts for assembled conductors with a common overall jacket.

Definition of shielding

Shielding of an electric power cable is the practice of confining the electric field of the cable to the insulation of the conductor or conductors. It is accomplished by means of strand and insulation shields.

Functions of Shielding

A strand shield is employed to preclude excessive voltage stress on voids between conductor and insulation. To be effective, it must adhere to or remain in intimate contact with the insulation under all conditions.

An insulation shield has a number of functions:
(a) To confine the electric field within the cable.
(b) To obtain symmetrical radial distribution of voltage stress within the dielectric, thereby minimizing the possibility of surface discharges by precluding excessive tangential and longitudinal stresses.
(c) To protect cable connected to overhead lines or otherwise subject to induced potentials.
(d) To limit radio interference.
(e) To reduce the hazard of shock. If not grounded, the hazard of shock may be increased.

Use of Insulation Shielding

The use of shielding involves consideration of installation and operating conditions. Definite rules cannot be established on a practical basis for all cases, but the following features should be considered as a working basis for the use of shielding.

Where there is no metallic covering or shield over the insulation, the electric field will be partly in the insulation and partly in whatever lies between the insulation and ground. The external field, if sufficiently intense in air, will generate surface discharge and convert atmospheric oxygen into ozone which may be destructive to rubber insulations and to protective jackets. If the surface of the cable is separated from ground by a thin layer of air and the air gap is subjected to a voltage stress which exceeds the dielectric strength of air, a discharge will occur, causing ozone formation.

The ground may be either a metallic conduit, a damp non-metallic conduit or a metallic binding tape or rings on an aerial cable, a loose metallic sheath, etc. Likewise, damage to non-shielded cable may result when the surface of the cable is moist, or covered with soot, soapy grease or other conducting film and the external field is partly confined by such conducting film so that the charging current is carried by the film to some spot where it can discharge to ground. The resultant intensity of discharge may be sufficient to cause burning of the insulation or jacket.

Where nonshielded nonmetallic jacketed cables are used in underground ducts containing several circuits which must be worked on independently, the external field if sufficiently intense can cause shocks to those who handle or contact energized cable. In cases of this kind, it may be advisable to use shielded cable. Shielding used to reduce hazards of shock should have a resistance low enough to operate protective equipment in case of fault. In some cases, the efficiency of protective equipment may require proper size ground wires as a supplement to shielding. The same considerations apply to exposed installations where cables may be handled by personnel who may not be acquainted with the hazards involved.

Operating voltage limits kV, above which insulation shielding is required
60 HERTZ POWER CABLE -

conductivity of sheath, spacing of conductors, and the current being carried all affect these recommendations. It is impossible to cover all these variations.

The following single conductor cables carrying alternating currents may, in general, be operated with multisheath grounds.

1. Shielded cables up to and including 250 kcmil with phases in separate ducts.

Cables in ac circuits should not be installed with each phase in separate magnetic conduits under any circumstances due to the high inductance under such conditions. Cables in a-c circuits should not be installed with each phase in separate metallic non-magnetic conduit when their size exceeds 4/0 unless the conduit is insulated to prevent circulating currents.

2. Shielded cables installed with all three phases in the same duct.

3. Cables of any size may be installed with multi-shield grounds, provided allowance is made for heating due to current induced in the shield. Cables carrying direct current may always be solidly grounded at more than one point, except where insulating joints are required to isolate earth currents or to permit cathodic protection.

Shields Grounded at One Point

Shields of single conductor cable carrying alternating current will have a potential buildup if grounded at only one point. The table below gives the maximum lengths which should be allowed between insulating joints in order to keep this potential below the maximum safe value of 25 volts.

They apply to cables operating at any 60 Hz a-c voltage. Many conditions will permit longer lengths between insulating joints, as for example, where cables are operating at less than full load.

The lengths given are from the grounded point to the insulating joint. If the mid-point of the section is grounded, the total length between insulating joints may be twice the length given.

Induced Shield Voltages, Currents and Losses

The Okonite Engineering Handbook gives formulas for calculating the induced voltage and shield loss for single conductor cables. These formulas neglect proximity loss, but are accurate enough for practical purposes.

It is assumed that the cables are carrying balanced currents.

For cables installed three per conduit use arrangement II. The spacing S in this case will be equal to the outside diameter of the cable increased by 20 percent to allow for random spacing in the conduit.

Maximum lengths for single conductor cables with shields insulated at joints and terminals and grounded at end of each section only.

These lengths are based on cables spaced on 7.5" centers operating at 75% load factor with ampacities given here for 15kV rated cables for 1/C per duct and for ampacities given here for 3 x 1/C cables per duct.

Size Conductor	One Phase per duct (ft)	Three Phases per duct (ft)
1/0......	1465......	4965.......
4/0......	1055......	3530.......
350......	820......	2610.......
500......	695......	2200.......
750......	595......	1800.......
1,000......	565......	—........
2,000......	420......	—........

100 AND 133% INSULATION LEVEL	
1. Single and multiple conductor cables with metallic sheath or armor	5kV
2. Multiple conductor cables with common overall discharge resisting jacket	5kV
3. Single conductor cables	2kV*
*Exception: Specially designed single conductor cables for specific applications	8kV

Grounding Shielded Cable

When installing shielded cable, metallic shielding must be solidly grounded. Where conductors are individually shielded, each must have its shielding grounded and the shielding of each conductor should be carried across every joint to assure positive continuity of a shielding from one end of the cable to the other. Where grounding conductors are part of the cable assembly, they must be connected with the shielding at both ends of the cable.

For safe and effective operation, the shielding should be grounded at each end of the cable and at each splice. For short lengths or where special bonding arrangements are used, grounding at one point only may be satisfactory.

All grounding connections should be made to the cable shield in such a way as to provide a permanent low resistance bond. Soldering the connection to the cable shield in usually preferable to a mechanical clamp, as there is less danger of a poor connection, loosening, or injury to the cable. The area of contact should be ample to prevent the current from heating the connection and melting the solder.

For additional security, a mechanical device, such as a nut and bolt, may be used to fasten the ends of the connection together. This combination of a soldered and mechanical connection provides permanent low resistance which will maintain contact even though the solder melts.

The wire or strap used to connect the cable shield ground connection to the permanent ground must be of ample size to carry fault currents.

Effect of Grounding Metallic Shield

The metallic coverings of cables must be grounded to provide satisfactory operating and safety conditions. As the method of grounding may affect the current carrying capacity, formulas for calculating losses and correcting the current carrying capacity for those losses may be found on pages 19 and 20 of Okonite's Engineering HandBook.

Installations of shielded single conductor cables must be studied to determine the best method of grounding. This is necessary as voltage is induced in the shield of a single conductor cable carrying alternating current due to the mutual induction between its shield and any other conductors in its vicinity. This induced voltage can result in two conditions:

1. Metal shields bonded or grounded at more than one point have circulating currents flowing in them, the magnitude of which depends on the mutual inductance to the other cables, the current in these conductors, and the resistance of the shield. This circulating current does not depend on the length of the cables nor the number of bonds, providing there are bonds at each end. The only effect of this circulating current is to heat the shield and thereby reduce the effective current carrying capacity of the cable. If the shield loss exceeds 5 percent or the copper loss, the current carrying capacity should be reduced.

2. Shields bonded or grounded at only one point will have a voltage built up along the shield. The magnitude depends on the mutual inductance to other cables, the current in all the conductors, and the distance to the grounded point. This voltage may cause discharge or create an unsafe condition for workmen. The usual safe potential is about 25 volts for cables having nonmetallic covering over the shield.

Multi-Grounded Shields

If operating conditions permit, it is desirable to bond and ground cable shields at more than one point, to improve the reliability and safety of the circuit. This decreases the reactance to fault currents and increases the human safety factor.

Some general recommendations may be made, but it must be remembered that variations in insulation thickness,